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DISEASES OF STRAWBERRIES ON THE MARKET

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CONTENTS

	Page
Introduction.....	1
Tabulation and analysis of data.....	2
Summary.....	7

INTRODUCTION

Strawberries are grown in all the States in the Union and are of commercial importance in at least 30 of them. In the number of carloads shipped to market the strawberry crop ranked fifth in 1924 (see Table 1) and also in 1925, among the six leading fruit crops of the United States. Whatever affects its quality or condition on arrival at market is therefore worth consideration. For this reason there is presented in this circular a study of the data furnished by inspection certificates of the food products inspection service of the Bureau of Agricultural Economics covering 5,370 carloads of strawberries examined at terminal markets during the 7-year period ended December 31, 1925. The total car-lot movement during this period was 96,860 carloads, hence the inspections dealt with here constitute 5.5 per cent of the total movement. Shipments by years and by States of origin are given in Table 2.

TABLE 1.—*Car-lot shipments of the six leading fruit crops for crop seasons shown.*¹

Crop	Carloads	Crop movement season
Apples.....	103,862	June 1, 1924, to June 30, 1925.
Grapes.....	69,938	June 1 to Dec. 31, 1924.
Oranges.....	59,759	Oct. 1, 1924, to Oct. 31, 1925.
Peaches.....	39,395	May 1 to Oct. 31, 1924.
Strawberries.....	18,973	Jan. 1 to Dec. 31, 1924.
Pears.....	16,253	Jan. 1 to Dec. 31, 1924.

¹ Division of statistical and historical research, Bureau of Agricultural Economics. Compiled from data of the fruit and vegetable division. Shipments shown as carloads include those by boat reduced to carload basis.

TABLE 2.—*Car-lot shipments of strawberries, by States of origin, 1919 to 1925, inclusive*¹

State	Crop-movement season ²						
	1919	1920	1921	1922	1923	1924	1925
	<i>Cars</i>	<i>Cars</i>	<i>Cars</i>	<i>Cars</i>	<i>Cars</i>	<i>Cars</i>	<i>Cars</i>
New York.....	112	362	244	328	301	345	202
New Jersey.....	326	559	425	274	187	402	126
Delaware.....	430	640	856	940	924	1,307	471
Maryland.....	611	787	1,069	1,646	1,916	2,155	1,088
Virginia.....	208	349	697	1,670	1,193	1,919	1,249
North Carolina.....	484	446	479	1,101	1,668	2,046	1,634
Florida.....	21	153	108	322	1,038	587	668
Illinois.....	80	98	74	260	224	367	295
Michigan.....	391	439	455	640	408	554	39
Missouri.....	1,081	318	466	1,963	872	990	1,497
Kentucky.....	132	239	387	772	827	467	312
Tennessee.....	1,099	1,182	1,693	3,607	3,279	2,902	1,637
Alabama.....	229	147	285	460	693	408	421
Louisiana.....	682	858	1,531	1,576	1,678	1,865	1,076
Arkansas.....	1,034	896	1,094	2,165	1,342	1,613	1,004
California.....	703	569	291	201	226	191	130
All other.....	482	448	541	791	1,028	853	406
Total.....	8,105	8,490	10,695	18,716	17,804	18,973	14,077

¹ Figures for 1919-1924 from Yearbook, United States Department of Agriculture, 1924, pp. 664-686; for 1925 from division of statistical and historical research, compiled from data of the fruit and vegetable division of the Bureau of Agricultural Economics. Shipments include those by boat reduced to a car-lot basis.

² The crop-movement season extends from Jan. 1 through December of a given year.

It can not be argued that conclusions based on so small a percentage necessarily apply to the whole commercial crop. On the other hand, and as pointed out for the apple inspections analyzed in an earlier publication,¹ these strawberry inspections do have some value as a measure of the condition of the crop, since out of the total of 5,370 carloads there were 1,669, or 31 per cent, which showed no disease. In 1919 and 1920 all of the cars examined showed disease, hence the percentages of rot given for those years (Table 3) are much less reliable as a measure of the true condition of the commercial crop than those given for any of the succeeding years.

All of the inspections were made at the request of financially interested persons, some to decide a question of grade, others to determine the amount of decay, and still others for sales purposes, that is, so that the car could be sold on the basis of Government inspection.

TABULATION AND ANALYSIS OF DATA

The tabulated results of the study are presented in the tables that follow. The analysis has been made by setting a definite percentage of disease, based on the certificate statement, for each carload in which disease occurred and classifying and totaling these percentages in various ways. The reliability of such a method is, of course, open to question, since, as pointed out in the earlier paper,¹ the certificate statement "frequently gives a range rather than a single average percentage and for strict accuracy should be interpreted by the inspector who wrote it." Nevertheless, the arbitrary fixing of such a percentage by anyone else for use in tabulation, whether with apple or with strawberry data, can be justified on the following grounds:

¹ ROSE, D. H. DISEASES OF APPLES ON THE MARKET. U. S. Dept. Agr. Bul. 1253, 24 pp., illus. 1924.

(1) In the settlement of controversies over the condition of shipments, financially interested persons make frequent and mutually satisfactory use of such a percentage deduced by themselves from the certificate statement; that is, they find it accurate and reliable for the settlement of deals in which money is involved.

(2) The certificate statements furnish more information about the condition of fruit shipments arriving on the market than is now available from any other source.

One objection to the use of such a percentage for carloads of strawberries is that the loads are usually made up of small lots from a number of growers and consequently are less likely to run uniform throughout the car than most other fruits, particularly apples and citrus fruits. It will be seen, however, that by using a single percentage for each car and analyzing the data in the manner already described certain plausible and likely relations are brought out which indicate that the objection is not so serious as it might at first appear to be.

Since *Rhizopus* causes more loss than all other rots combined, it is the only one for which a percentage is given separately. Other rots found by the inspectors and covered by the column heading "All other rots" include gray-mold rot, leather rot, and various unidentified rots, probably *Rhizoctonia* brown rot and tan brown rot.²

TABLE 3.—*Rot in carloads of strawberries inspected on the market, shown by years for the 7-year period ended October 1, 1925, for all strawberry-shipping States except Florida*

Year	Total carloads inspected				Carloads showing rot				Carloads showing no rot
	Number	Average percentage of rot			Number	Average percentage of rot			
		Rhi-zopus rot	All other rots	Total		Rhi-zopus rot	All other rots	Total	
1919.....	85	10.6	10.0	20.6	85	10.6	10.0	20.6	-----
1920.....	251	8.1	7.3	15.4	251	8.1	7.3	15.4	-----
1921.....	420	5.7	4.9	10.6	405	6.0	5.0	11.0	16
1922.....	1,151	3.7	2.9	6.6	864	5.0	3.6	8.6	287
1923.....	942	4.7	3.1	7.8	810	5.4	3.6	9.0	132
1924.....	1,448	1.7	.9	2.6	726	3.5	1.7	5.2	722
1925.....	1,073	1.3	.9	2.2	560	2.5	1.7	4.2	513
Total or average.....	5,370	3.4	2.5	5.8	3,701	4.9	3.5	8.4	1,669

Table 3 shows that for the 7-year period as a whole the average percentage of rot in all carloads inspected was 5.8 per cent; calculated only for those which showed rot, it was 8.4 per cent; calculated on either basis and counting total rot as 100 per cent, that caused by *Rhizopus* amounted to approximately 58 per cent, and that by all other fungi to approximately 42 per cent, of which the greater part was caused by gray mold. Leather rot was important in Arkansas and Tennessee in 1922 and 1923, both of which years were "wet" ones in those States; that is, the rainfall there during the strawberry-picking season was heavier than in 1924 and 1925 (Table 6) and on the average heavier than normal for the strawberry sections of those States.

² DODGE, B. O., and STEVENS, N. E., RHIZOCTONIA BROWN ROT AND OTHER FRUIT ROTS OF STRAWBERRIES. Jour. Agr. Research 28: 643-648, illus. 1925.

The Florida figures are given separately (Table 4) because part of the inspections of strawberries from that State were made on carloads and part on lots of one to six or more "pony refrigerators."³ It has been found impracticable to separate the two, and it would be inaccurate to lump both as carload inspections or to attempt to reckon from the basis of some hypothetical number of pony refrigerators to a carload. It will be noted that the total rot for Florida shipments was 10 per cent; for only those which showed rot, 13.4 per cent. Calculated either way, *Rhizopus* rot constituted 75 per cent of the total rot.

TABLE 4.—*Rot in shipments of strawberries from Florida for the 7-year period ended October 1, 1925*

Total shipments inspected				Shipments showing rot				Ship- ments showing no rot
Number	Average percentage of rot			Number	Average percentage of rot			
	Rhizopus rot	All other rots	Total		Rhizopus rot	All other rots	Total	
387-----	7.5	2.5	10.2	286-----	10.2	3.2	13.4	101

Referring to Table 5 and Figure 1, it will be seen that combining the Arkansas and Tennessee series for 1922 and 1923 in one group and those for 1924 and 1925 in another, the total rot for the first period was 10.6 per cent and for the second 1.9 per cent. Corresponding

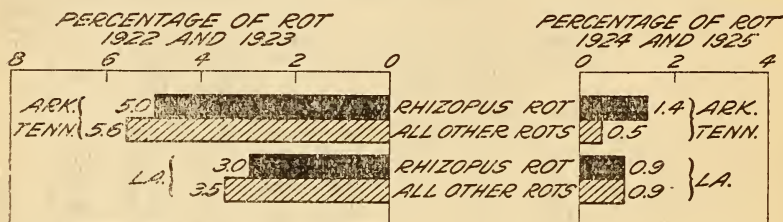


FIG. 1.—Percentage of *Rhizopus* rot and of all other rots in carload shipments of strawberries from Arkansas, Tennessee, and Louisiana for two "wet" years, 1922 and 1923, and two "dry" years, 1924 and 1925

figures for Louisiana are 6.5 per cent and 1.8 per cent.; that is, in the two wet years for all three States the total average rot was nearly five times as great as in the two succeeding dry years. (Rainfall is shown in Table 6.) What is more interesting, however, is that in the wet years in Arkansas and Tennessee *Rhizopus* was less than half of the total rot, but in the dry years more than two-thirds. This difference may be due to several causes, but is undoubtedly due most of all to the high percentage of leather rot during the wet years. Other noteworthy facts are that all rots were less serious in the dry than in the wet years and that *Rhizopus* rot always occurred to some extent no matter what the season. In Louisiana, where leather rot

³ Pony refrigerators are double-walled portable wooden chests large enough to hold 64 or 80 quarts of strawberries and about 200 pounds of ice. The ice is contained in a vertically placed tank at the center and in a large can over the top just under the lid. These refrigerators are used extensively in Florida and very little anywhere else.

is practically negligible, Rhizopus rot made up about one-half of the total rot in all the years covered by this analysis.

Rhizopus rot thus stands out in all the tables as the one rot which, over a period of years, caused most of the trouble to those concerned in the marketing of strawberries in carload lots. This is not surprising, since the occurrence of Rhizopus is known to depend largely on handling methods and the quality of refrigeration in transit, the fungus being apparently unable to enter except through skin breaks or to develop or spread to any marked extent if the temperature is kept below 50° F.⁴

TABLE 5.—Percentage of Rhizopus rot and of all other rots in carloads of strawberries from Arkansas, Tennessee, and Louisiana, 1922 to 1925, inclusive

State	Percentage of rot											
	1922		1923		1924		1925		1922 and 1923		1924 and 1925	
	Rhi-zopus rot	All other rots	Rhi-zopus rot	All other rots	Rhi-zopus rot	All other rots	Rhi-zopus rot	All other rots	Rhi-zopus rot	All other rots	Rhi-zopus rot	All other rots
Arkansas.....	3.3	6.2	3.0	6.7	0.3	0.3	0.6	0.5	5.0	5.6	1.4	0.5
Tennessee.....	6.7	5.7	5.9	3.3	3.3	.5	1.6	.3				
Louisiana.....	4.5	1.2	1.9	1.6	.5	.7	1.7	.9	3.0	3.5	.9	.9

TABLE 6.—Rainfall in strawberry-growing sections of Arkansas, western Tennessee, and Louisiana during the picking season, 1922 to 1925, inclusive

State	Rainfall (inches)				
	1922	1923	1924	1925	Mean
Arkansas: ¹					
Little Rock.....	4.74	10.50	2.44	1.42	5.10
Tennessee: ¹					
Covington.....	7.10	10.68	4.18	2.19	4.35
Jackson.....	6.38	7.41	5.83	1.86	4.15
Louisiana: ¹					
Amite.....	12.45	19.28	8.17	3.04	10.31
Hammond.....	7.44	12.80		6.34	8.59

¹ May. Picking sometimes begins late in April or extends into June, but the greater part of it is practically always done in May.

² April and May. Picking sometimes begins in March. The bulk of the crop moves in April and May.

In Tables 7 and 8 the percentages of rot are shown by States. From these it is seen that shipments were inspected from 28 States and Canada and that of the 10 States represented by 100 carloads or more the 4 whose shipments showed the worst decay were all southern.

⁴ STEVENS, N. E., STRAWBERRY DISEASES. U. S. Dept. Agr. Farmers' Bul. 1458, 10 pp., illus. 1925. Also earlier publications by the same author.

TABLE 7.—*Rot in carloads of strawberries inspected on the market, shown by States, for the 7-year period ended October 1, 1925, for all strawberry-shipping States except Florida*

State	Total carloads inspected				Carloads showing rot	Carloads showing no rot
	Number	Average percentage of rot				
		Rhizopus rot	All other rots	Total		
Alabama.....	104	9.9	4.5	14.4	100	4
Arkansas.....	574	2.6	4.6	7.2	396	178
California.....	5	3.8	4.2	8.0	5	
Delaware.....	189	2.5	3.3	5.8	123	66
Georgia.....	1		17.0	17.0	1	
Illinois.....	9		.6	.6	3	6
Indiana.....	17	.4	1.7	2.1	11	6
Iowa.....	12	1.2	1.7	2.9	10	2
Kansas.....	1	15.0		15.0	1	
Kentucky.....	207	4.5	2.9	7.4	146	61
Louisiana.....	1,628	2.5	1.2	3.7	1,145	483
Maryland.....	406	1.3	1.3	2.6	259	147
Michigan.....	59	8.8	6.1	14.9	56	3
Minnesota.....	1		3.0	3.0	1	
Mississippi.....	73	1.5	3.6	5.1	56	17
Missouri.....	402	2.4	.9	3.3	166	236
Montana.....	1	3.0		3.0	1	
New York.....	31	4.1	2.9	7.0	27	4
North Carolina.....	184	1.1	1.4	2.5	111	73
Ohio.....	13	10.1	.7	10.8	8	5
Oregon.....	6		1.1	1.1	5	1
Pennsylvania.....	3	.4	.3	.7	1	2
Tennessee.....	845	5.3	4.4	9.7	674	171
Texas.....	4	.2	1.3	1.5	3	1
Unknown.....	206	11.4	2.7	14.1	181	25
Utah.....	1	1.0		1.0	1	
Virginia.....	319	1.1	.9	2.0	171	148
Washington.....	12	4.1	2.4	6.5	10	2
Wisconsin.....	30	2.8	1.4	4.2	15	15
Canada.....	27	.6	5.7	6.3	14	13
Total or average.....	5,370	3.4	2.5	5.8	3,701	1,669

TABLE 8.—*Rot in carloads of strawberries during the 7-year period ended October 1, 1925, shown for the 10 States represented in the inspection records by 100 or more carloads*

State	Total carloads inspected		Carloads showing rot	
	Number	Average percentage of decay	Number	Average percentage of decay
Alabama.....	104	14.4	100	15.0
Tennessee.....	845	9.7	674	12.0
Kentucky.....	207	7.4	146	10.5
Arkansas.....	574	7.2	396	10.4
Delaware.....	189	5.8	123	8.9
Louisiana.....	1,628	3.7	1,145	5.3
Missouri.....	402	3.3	166	8.0
Maryland.....	406	2.6	259	4.2
North Carolina.....	184	2.5	111	4.1
Virginia.....	319	2.0	171	3.8

SUMMARY

There is presented in this circular a study of data furnished by certificates of the food products inspection service of the Bureau of Agricultural Economics covering 5,370 carloads of strawberries examined at terminal markets during the 7-year period ended December 31, 1925.

Inspections covered 5.5 per cent of the total carload movement of strawberries for the 7-year period. Nearly one-third of the inspected cars showed no rot.

The average percentage of rot in all carloads inspected was 5.8; in only those which showed rot, 8.4. Rot caused by the fungus *Rhizopus* amounted to approximately 58 per cent of all rot found and that caused by all other fungi to approximately 42 per cent.

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